

1810. Kritische Bemerkungen zu den Becherflechten in der *Lichengraphia universalis* von Dr. Erik Acharius. 19 p. in-4to.
Most of the remarks of Flörke are very just, and Acharius has attended to them in his Synopsis.
1811. Einige Lichenen von Kamtschatka und der benachbarten Inseln. Description of eighteen species of common lichens, collected in Asiatic Russia by Tilesius.
3. In *Beiträge zur Naturkunde* von Weber, Bd. ii. 1810:
Einige Bemerkungen über das Unbestimmte des Begriffs der Varietäten im Pflanzenreiche. 27 p. in-8vo.
Beschreibung der braunfrüchtigen deutschen Becherflechten. 64 p. in-8vo.
4. In Beisters *Berliner Monatschrift*, 1804: Einige allgemeine Bemerkungen über das Salzburgische Gebirge.
5. Deutsche Lichenen gesammelt und mit Anmerkungen herausgegeben von H.-G. Flörke. Atlas in-folio, text in-8vo; liv. i.-iii. Berlin, 1815; liv. iv.-vi. Rostock, 1819; liv. vii.-x. Rostock, 1821.
6. De Cladoniis, difficillimo Lichenum genere, commentatio nova. Rostochii, 1828, in-8vo.
7. Cladoniarum exemplaria exsiccata, commentationem novam illustrantia. Rostock, 1829, fasc. i.-iii. (60 N^o).
8. In the Calendar of Mecklenburg, 4to, a very great number of popular articles on physical geography, astronomy, and palæontology.
9. In the *Freimüthliche Abendblätter* (a weekly journal of popular science at Mecklenburg), many articles on popular natural history.
10. In *Neue Annalen der Mecklenburgischen Landwirthschaft-Gesellschaft*, for 1820, a long dissertation on spontaneous generation in the animal and vegetable kingdoms. (Flörke admitted spontaneous generation, as did most of the writers of his time.)
11. In the journal *Vandalia* of Dr. Masius, 1819, fasc. ii.-vi., many notices of physics and of meteorology.

In terminating this biographical notice of Flörke, it is my pleasing duty to offer my best thanks to my excellent friend M. J. Roeper, Professor of Botany in the University of Rostock, who, during my sojourn in that town, with the greatest courtesy procured me every kind of information concerning its former Professor.

XXXV.—*On the Young Stages of a few Annelids.*

By ALEXANDER AGASSIZ*.

[Plates V. & VI.]

THE study of immature animals has become so important that, before proceeding to my subject, it may be of some interest to those engaged in investigating marine animals, to know how the young may be collected. Johannes Müller was the first who successfully employed surface-dredging with a fine gauze hand

* Reprinted from the 'Annals of the Lyceum of Natural History of New York,' vol. viii., June 1866.

net; he has been followed with eminent success by many of his pupils, and now scooping the surface of the sea in search of diminutive animals, scarcely to be recognized with the naked eye, is one of the most profitable sources of supply for recent investigators at the sea-shore. Baur* has introduced fishing with the gauze net by sinking it to any desired depth; and this promises to be a fruitful mode of finding what cannot be reached with a hand net. Meyer and Möbius†, in their investigations of the Fauna of the Bay of Kiel, have even attempted, with remarkable good fortune, to pump up from the vicinity of the bottom any animals there abounding.

As a rule, the habits of the young marine animals are so utterly different from those of the adult, that we cannot expect to find them together, and must not search for the young in the retreats where lie concealed the adult Crustacea, in the mud flats or sandy beaches where are buried Annelids and Mollusca, along the rocky shores where so many Gasteropods abound, or under seaweeds and stones, the hiding-places of both Annelids and Mollusks as well as Crustacea. We must not look in rocky pools frequented by Starfishes, Sea-urchins, and the like for young Echinoderms; the young Polyps are not always to be found growing up by the side of their parents; neither can we expect to find the young Cod, Goosefish, Lumpfish, Flounder, Cottoids, and Perches on the feeding-grounds frequented by the fishermen in search of the adult. The young fishes abound close inshore, along sandy flats heated by the sun, seeking to avoid the dangers which would beset them in deeper waters; and they can scarcely be recognized for what they really are except by the most practised eye. Thus the earlier stages of most marine animals are passed under circumstances totally different from those of the adult. When the adults are sedentary in their habits, and capable of very limited motion, the young are almost always endowed with corresponding freedom, leaving them entirely at the mercy of the winds and currents. On the contrary, in the class where we have the greatest freedom of movements and least sedentary habits, we find the young, for the most part, fixed to the ground and incapable of any motion. What greater contrast can there be in this respect than the early stages of Hydroid Medusæ, when, plant-like, they remain for ever attached to one spot, giving rise to Medusæ endowed with the most varied and graceful movements, and often carried about helpless by the wind and tide.

* "Beiträge zur Naturgeschichte der *Synapta digitata*," in Verhandl. der K. L. C. Akad.: 1864.

† Fauna der Kieler Bucht.

The young of many of our Annelids present a similar contrast to the adult, the latter passing their existence buried in tubes sunk in the mud or sand, while in their early stages they are free and nomadic, and swarm near the surface of the sea. Who would have thought of looking for young Echinoderms among those erratic beings which perform such a conspicuous part in the phosphorescence of the sea, until the wonderful researches of Müller led the way to a field of investigation which has revealed changes of the most astonishing nature! The young Crustacea, until quite advanced, find their way to the top of the water, where they swim about in company with embryo mollusks, both very different in appearance and in their habits from the adults.

From the few complete embryologies we possess of the lower marine animals, it is apparent that there has not been, up to this time, any systematic method of working. Artificial fecundation can do much towards adding to our knowledge of the early stages of marine animals; but any one who has lived near the sea-shore and endeavoured to keep alive these tiny creatures, will soon find in this method insurmountable obstacles to pursuing his investigations beyond very narrow limits. The only way is to go to the fountain-head at once, to make one's self familiar with the currents at all hours of the tide and under all possible influences of wind, to notice the place where opposite currents meet and throw into long bands the wealth of animal life they have swept along, to become so perfectly familiar with what you may expect to find under certain conditions that no time shall be lost in looking for the most favourable spot, which otherwise you would only stumble upon accidentally. The habitat of the adult animals should be carefully observed, so that, by surface-dredging with the fine gauze hand net in the vicinity of their abodes, and by a close attention to the direction which the currents take from these places, at the time of breeding we can often obtain specimens at all ages and of all sizes, till they have ceased to be nomadic or have assumed the habits they retain in their adult condition.

According to the nature of each locality, spots are easily found where the currents which skirt along the shores are compelled to pass. Projecting points of land are barriers during certain hours of the day, and everything brought floating with the tide along their shores will accumulate, until it forces its way round or over the obstacles. Narrow passages between islets and the shore, through which the tide rushes with great rapidity, will give us a synopsis as it were of all that can be found in the vicinity. When the wind blows constantly from the same direction, it will heap up on the lee shore anything floating on the

surface, so that frequently the examination of a few rods will give us at once what otherwise we should find only after a protracted search.

Violent storms, which throw upon the beaches masses of seaweed, furnish a rich harvest of small animals, attached to the fronds, or concealed between the roots, only to be found in at other times inaccessible hiding-places. The roots of *Laminaria* are the resort of thousands of young Echinoderms, Annelids, Crustacea, and Mollusks after they have ceased to swarm near the surface of the water, and have assumed somewhat the habits of the adult. Not even the dredge will root these up, and we must snatch at the favourable chances an opportune storm throws in our way.

I have already shown, in my different papers on the Embryology of Echinoderms* and Acalephs†, how useful knowledge of this kind proved in order to complete missing links in the history of their development. In the following pages will be given some of the results obtained for a few Annelids by a similar mode of procedure.

Planaria.

Before the observations of Müller‡ on the development of Planarians, the embryos had not been found to differ materially from the adult; according to Siebold§, Schmidt||, and Quatre-fages¶, they differed principally in size, and no trace of metamorphosis could be seen; similar results have been obtained by Van Beneden**, Keferstein and Ehlers††, and Claparède ‡‡.

* "On the Embryology of *Astracanthion berylinus*, Ag.," in Proc. Am. Acad., April 14, 1863. "On the Embryology of Echinoderms," in Mem. Am. Acad. ix. 1864. "Embryology of the Starfish," in vol. v. of Agassiz's Cont. Nat. Hist. of U. S., 1865.

† North American Acalephæ: No. 2 of Illustrated Catalogue of Museum of Comparative Zoology: 1865.

‡ "Ueber eine eigenthümliche Wurmlarve aus der Classe der Turbellarien u. aus der Familie der Planarien," in Archiv f. Anat. u. Phys. 1850, p. 485, pl. xii., xiii.

§ Wirbellose Thiere, in *Siebold* u. *Stannius* Vergleichende Anatomie, p. 171.

|| Die Rhabdocœlen Strudelwürmer des süßen Wassers, beschrieben u. abgebildet: 1848.

¶ "Mémoire sur quelques Planaires marines," in Ann. Scien. Nat. sér 3, 1845, iv.

** Recherches sur la Faune littorale de la Belgique. Turbellariés de la côte d'Ostende: 1860.

†† Zoologische Beiträge gesammelt im Winter 1859-60, in Neapel u. Messina: 1861.

‡‡ Beobachtungen über Anatomie u. Entwicklungsgeschichte wirbelloser Thiere, an der Küste von Normandie angestellt. Leipzig, 1863.

Müller's observations first showed the existence of a metamorphosis in *Planaria*, while Leuckart and Pagenstecher* subsequently proved beyond doubt the existence of still more striking changes in *Pilidium*, of a sort of alternate generation giving rise to *Nemertes*, as previously suggested by the observations of Müller †, Busch ‡, Gegenbaur §, Wagener ||, and Krohn ¶—changes reminding us of a somewhat similar process in the development of an Echinoderm from a Pluteus. To these evidently dissimilar modes of development I still have to add the transformations of *Nareda*, as shown in a subsequent part of this paper, resembling the usual mode of development of Annelids; also a sort of retrograde development of a species of *Planaria* quite analogous to that more fully described in *Nareda*, where we have a gradual extinction, with advancing age, of very distinct articulate features of the young. As in *Nareda*, we find in this *Planaria* plainly marked articulations when young, which become less and less distinct with advancing development—a striking contrast to the evolution shown to exist in Planarians by Müller, and to the usual mode of growth in this family, where the young so early resemble the adult.

On examining a string of eggs, mistaken at first for those of some naked mollusk, I was surprised to find young *Planaria* in different stages of growth, with a ramifying digestive cavity somewhat similar to that of adult specimens, but showing besides one distinct articulation for each spur of the digestive cavity. The eyes were well developed; and when the young became free, the articulations were still distinct, and the ramifications of the digestive cavity sufficiently advanced to enable me to determine with tolerable certainty the species to which these young belonged—probably the *Planaria angulata*, Müll.**

In the youngest specimen observed (Pl. V. fig. 1) the spurs of the digestive cavity were quite prominent, eleven in number (the first trace of the ramifications of the adult); each spur was

* "Untersuchungen über niedere Seethiere. *Pilidium* die Larve einer Nemertine," in Arch. f. Anat. u. Phys. 1858, p. 569, pl. xix.

† "Ueber verschiedene Formen von Seethieren," in Arch. f. Anat. u. Phys. 1854, p. 81. "Bericht über einige neue Thierformen der Nordsee," in Arch. f. Anat. u. Phys. 1846, pl. v.

‡ Beobachtungen über Anatomie u. Entwicklung einiger wirbelloser Thiere. Berlin, 1851.

§ "Bemerkungen über *Pilidium gyrans*, *Actinotrocha branchiata* und *Appendicularia*," in Zeitschr. f. wiss. Zool. 1853, v. p. 346.

|| "Ueber die *Mesotrocha sexoculata* von Wilh. Busch," in Arch. f. Anat. u. Phys. 1847, p. 187.

¶ Archiv f. Anat. u. Phys. 1856, p. 78. "Ueber *Pilidium* u. *Actinotrocha*," in Archiv f. Anat. u. Phys. 1858, p. 289.

** O. F. Müller, 'Zoologica Danica.'

placed in a distinctly marked transverse ring. The two anterior and posterior rings were much larger than the others. In this stage the young *Planaria* scarcely answers to its name; it is almost cylindrical, and only slightly compressed. In fig. 2 the processes are larger and more distinctly developed, and the young worm has become considerably flattened. It seems scarcely necessary to refer to the opinion advanced by Girard*, that the Planarians are naked Gasteropods.

On the Adult of Lovén's Annelid Larva (Nareda, Gir.?) †.

Although Lovén was the first to publish observations on the development of Annelids proper, as early as 1842 ‡, when he traced the development of an Annelid, supposed at the time to be the larva of some *Nereis*-like animal, yet up to the present day his observations have not been confirmed, in spite of the many memoirs we now possess on the metamorphosis of several families of true Annelids. Milne-Edwards, who followed closely upon Lovén with a most exhaustive history of the development of *Terebella* §, laid the foundation of generalizations on the mode of formation and norm of succession of rings in the young Annelids, which subsequent observations have completely confirmed. These were somewhat different from what would seem to be logically deduced from the observations of Lovén; so that it is of considerable interest to have the observations of the latter repeated, to show that the development of this larva does not differ very materially from the general mode of evolution observed in other Annelids.

The large disk of the anterior extremity in Lovén's larva was regarded by Milne-Edwards as simply due to the distention of that portion of the young Annelid, similar to what he had often observed in some of the younger stages of *Terebella* while in motion. Larvæ with similar disks have since been observed by Sars, Busch, Müller, and Claparède, which are known to be the young of *Polynoë*. It was therefore, to judge from the general resemblance of these larvæ, most natural to associate Lovén's larva with those of *Polynoë*, as has been

* "Researches upon Nemerteans and Planarians.—I. Embryonic Development of *Planocera elliptica*," in Journ. Acad. Nat. Sciences, Phil. 1854. "On the Development of *Planocera elliptica*," in Proc. Bost. Soc. N. H. iii. p. 348.

† Charles Girard, in 'Synopsis of Marine Invertebrates of Grand Manan,' by W. Stimpson, in Smithson. Cont. 1853.

‡ "Jagttagelse öfver metamorfos hos en Annelid," in K. Vet. Akad. Handl. Stockholm, 1840, p. 93; Archiv f. Naturg. 1842, i. p. 302; also in Ann. d. Scien. Nat. sér. 2, 1842, xviii. p. 288.

§ "Observations sur le développement des Annélides," in Ann. d. Scien. Nat. 1845, iii. p. 145.

done by Claparède in his classification of Annelid larvæ. From what is shown hereafter (and we have, as far as I know, no exceptions to this in the embryology of Annelids) there are points of difference showing at once that the association is not a natural one. The oldest stage figured by Lovén has as yet no trace of any feet or bristles; and the only feature by which it might possibly be associated with the Nereidæ or Eunicææ, as has been done by Lovén, is the presence of two short antennæ at the anterior extremity. We should expect, from what has been shown thus far by all writers on young Annelids, to find in somewhat more advanced stages that these tentacles have considerably increased in length; but such is not the case in the specimens of a closely allied species which I have had the opportunity to observe, and to keep alive long enough to leave but little doubt that Lovén's larva does not belong to the Rapacious or Tubicolar Annelids, but to the Turbellariæ, and probably to some Nemertean genus like *Nareda* of Girard.

We find, in stages subsequent to those figured by Lovén (figs. 14 and 17), that the antennæ gradually disappear by a sort of retrograde metamorphosis, similar to that of *Terebella*, observed by Milne-Edwards and Claparède, where the young, resembling far more the normal type of rapacious Annelids than the adult, lose their few rudimentary organs of sense and locomotion soon after they have commenced building their case. Lovén observes that the absence of feet and bristles prevented him from ascertaining the genus to which his young Annelid belonged; while it is this very absence of feet and bristles, as well as the distinct separation of the digestive cavity into œsophagus, stomach, and intestine, plainly described by him in his young worm, which should have guided him, as well as subsequent writers on this subject, in referring the larva to its proper place. Had it not been for the deceptive appearance caused by the temporary presence of antennæ and their resemblance to *Polynoë* larvæ, this would undoubtedly have been done long ago, especially when taking into consideration the differentiation of the digestive cavity, so prominent in Lovén's larvæ: this separation takes place in other Annelid larvæ long after the family (and sometimes even the generic) characters have been fully developed. The early growth of bristles, and the resemblance of the young larvæ of *Polynoë* to the adult at so young a stage, should at once have directed attention to such an anomalous type as that of Lovén's, having no feet or bristles long after the young worm had lost its embryonic character as well as all trace of the row of vibratile cilia round the head.

The passage of Lovén's figures from the condition with a disk

to the most advanced stage he observed is somewhat abrupt. I have been able to supply this defect in the observations given below (see figs. 7-16). Although my larvæ differ somewhat from those of Lovén, there can be no question of the family identity of the two. In the youngest larva (fig. 3) we find, as observed by Lovén, no trace as yet of any articulations; but we have, besides the large circle of vibratile cilia round the anterior extremity (*v*) described by Lovén, a similar powerful ring (*v'*) round the posterior extremity. This anal circle either does not exist in Lovén's larva, or must have escaped his attention. Our larva is, like Lovén's, transparent as glass; it has in addition, following the course of the two vibratile rings, a single row of most brilliantly coloured orange pigment spots of different shades and sizes; similar pigment spots are scattered in three unequal rows along the unarticulate body between the anal and anterior vibratile chords; there is besides a crescent-shaped row of spots along the posterior edge of the mouth (*m*). The two jet-black eye-spots (*e*) on each side of the summit of the disk are also found in our larva (seen only when facing the ventral or dorsal side, as in fig. 7). The eyes have a totally different appearance from the other pigment spots found along the body and vibratile rings. They are apparently connected with a nervous ganglion sending off delicate branches to the anterior vibratile ring. The mouth opens behind the anterior vibratile chord, leading into a well-defined œsophagus communicating with a stomach, which is distinctly separated at its posterior extremity from the intestine; the latter opens externally in the middle of the anal vibratile chord, placed at the base of the anal ring; this is slightly conical, and projects somewhat beyond the vibratile chord.

Lovén distinctly states that the rings are formed immediately at the base of the anterior disk behind the mouth: this is probably an error of observation, owing to the advanced period at which the articulations first commence; or the rings are simply folds due to contraction. He describes all the rings of his young larva (Lovén, fig. 2) as made up of four pieces, and represents the same thing again in his fig. 5. Nothing of the kind could be seen in the formation of the rings in our larva (figs. 4 & 5). In somewhat more advanced stages, after the first rings were distinctly developed, I had no difficulty in finding near the anal ring a small part of the body of the worm in which the articulations became more and more distinct as they were more distant from the anus (fig. 6), showing beyond doubt that new rings are formed between the anal rings and the older anterior rings, as in other Annelid larvæ, and not immediately below the disk near the mouth as stated by Lovén. The larvæ figured by

Lovén were probably not in a healthy condition; and as he himself mentions his inability to keep them beyond a few days, it seems probable that the peculiar composition of the rings (of four pieces) is simply due to contraction. The same thing has frequently been observed in our own larvæ; and those thus showing this apparent division (succeeding a stage where nothing of the sort existed) invariably died soon afterwards, as was the case with Lovén's young Annelids.

As far as I could ascertain, a number of rings make their appearance at once (fig. 4), and are the more distinct the nearer they are placed to the mouth; they appear at first like faint transverse lines, readily mistaken for furrows formed by contraction. In the present stage (fig. 4) we find otherwise no striking difference from the previous one; the posterior part is somewhat more elongated, and we have the lines of ventral and dorsal spots increased in number. With the growth of the larvæ the pigment spots of the body become smaller and more irregularly scattered (fig. 5), while there is no diminution as yet in the size and brilliancy of the pigment spots of the oral and anal vibratile rings. As the body elongates, the articulations become more distinct, the digestive cavity narrower; and the disproportion in width between the oral disk and the diameter of the body attains its maximum in the present stage; the anal ring has become somewhat more prominent than in the previous stage. The part of the body as yet not divided into rings can be plainly seen in fig. 6 placed next to the anus; the whole of the stomach is lined with powerful vibratile cilia, particularly well developed at the opening of the œsophagus into the stomach, and at the beginning of the intestine (*c*, fig. 6).

There appear at the stage of fig. 4, in front of the eyes, two small tentacles (*t*) (as observed by Lovén), placed nearly at the extremity of the young worm. The body of the larva now takes a rapid development; and in the stages next represented here, fig. 7 (which, with the previous stage, fig. 5, are phases not fully described by Lovén), we find as many as forty-three rings, and the pigment spots of the body more numerous than in previous stages. The lengthening of the body is accompanied by a decrease in the relative size of the anterior disk, no longer so much out of proportion as to give the larva the hammer-shape it possessed before; the part of the disk anterior to the vibratile ring has somewhat elongated; the mouth (*m*) when seen from the ventral side (fig. 8) appears quadrangular with rounded edges; it is situated close behind the anterior vibratile chord, and edged on the posterior extremity with a row of large pigment-cells.

We now come to a series of changes plainly showing the

passage from the stage represented by Lovén in his fig. 5 to that of his fig. 6. Although the body of the young worm is much elongated, the number of rings (fig. 9) has not greatly increased; they are further apart, and there is a tendency in the stomach (which occupies nearly the whole width of the body) to become folded, so as to correspond to the articulations; the anterior part of the head has greatly elongated, and the general appearance of the young worm reminds us somewhat of the larva of *Sipunculus nudus* figured by Keferstein and Ehlers. The vibratile rings are greatly reduced, the antennæ have slightly increased in length, and the head of the worm presents a certain resemblance to a Nereid or some allied form. The swelling of the posterior extremity has also been reduced, and the anal vibratile chord scarcely projects beyond the line of the body. The pigment spots of the rings have diminished in number, but slightly increased in size; and the brilliant row of spots of the oral and anal rings is beginning to fade, the vibratile cilia are losing much of their activity, and the little worm, though still capable of swimming freely about, and often caught at this stage with the dip net, moves quite slowly and has gradually lost, with the extension of the posterior part of the body, the rapidity of motion it enjoyed in the earlier stages (figs. 3, 4). When kept in confinement they are often found at the bottom of the vessel coiled up, and when disturbed creep slowly away by undulations of the body, assisted by the remnants of the vibratile rings. In a somewhat more advanced stage (fig. 10) the pigment spots have further diminished in size as well as number, the convolutions of the digestive cavity are more distinct, the antennæ have decreased in length, and the vibratile rings have lost their former power. In a subsequent stage (fig. 11) the head has become more distinct, the anterior vibratile ring scarcely exceeds the diameter of the body, and the antennæ are quite prominent. The little worm is only rarely fished up in this stage, swimming about very slowly, and becoming somewhat more active when creeping upon the bottom, where they now prefer to remain. This is their most advanced nomadic stage; and, from their subsequent habits, it is necessary to keep them in confinement in order to follow their later changes.

We find in fig. 11 the pigment spots becoming smaller than in preceding stages: the convolutions of the digestive cavity, which has acquired a light yellowish colouring, are extremely well defined. Up to this time we have still no trace of feet, bristles, or appendages of any sort, except the two tentacles of the head; and were it not for these, it would seem as if the young worm were the larva of some *Nemertes*-like animal, not-

withstanding the different development of Nemerteans observed by Müller*, Busch†, Gegenbaur‡, Krohn§, Wagener||, Leuckart and Pagenstecher¶, and others, which, when we know more of the general plan of development of Annelids, may after all not present any greater differences, when compared with the present type of growth, than we find in the embryology of Echinoderms, between the plutean and sedentary mode of development. There can be no doubt that we have in Annelids as in Echinoderms closely allied genera undergoing a widely different metamorphosis—an additional analogy between these two classes, but not, it seems to me, a sufficient reason for uniting Echinoderms with worms, as has been urged with so much ingenuity by Huxley. The observations of Desor** hint at some such widely different transformations for the Nemerteans; but his observations are too inaccurate to afford any data for a satisfactory analysis.

The persistence of the antennæ and absence of feet and bristles would show that it belonged to some genus of Annelids as yet not described, the only Annelid without setæ being *Phoronis* of Wright††, to which, however, from the descriptions given by Allman in his Freshwater Polyzoa‡‡, and by Van Beneden§§, it has not the slightest relationship. On examining subsequent stages this stumblingblock is found gradually to vanish by a sort of retrograde development; and as the little worm grows older it loses little by little the embarrassing appendages, and shows, in the most advanced stages thus far observed, a tolerably close resemblance to such well-known Nemerteans as the *Nareda* of Girard||| and some of the species of *Polia* figured by Quatrefages¶¶ in the 'Voyage en Sicile,' although as yet I have not been able to trace in the embryo worm anything of the complicated structure of the Nemerteans.

The little worm (fig. 11) has now attained a length of one

* *L. c.*, in Archiv f. Anat. u. Phys. 1847.

† Entwicklung u. s. w. *l. c.* p. 107.

‡ *L. c.*, in Zeitsch. f. wiss. Zool. 1853, v. p. 346.

§ *L. c.*, in Archiv f. Anat. u. Phys. 1856, p. 78.

|| Archiv f. Anat. u. Phys. 1857, p. 204.

¶ Archiv f. Anat. u. Phys. 1858, p. 569.

** "On the Embryology of *Nemertes* . . ." in Proc. Bost. Soc. Nat. Hist. vol. vi. p. 1, 1848.

†† Edinb. New Phil. Journ. 1857, v.

‡‡ A Monograph of Freshwater Polyzoa, p. 55, note.

§§ "Note sur un Annélide Cephalobranche sans soies, désigné sous le nom de *Crepina*," in Bull. Acad. Roy. de Belgique, sér. 2. v. no. 12.

||| C. Girard, in Smiths. Cont. 1853.

¶¶ "Mémoire sur la famille des Némertiens," in Recherches Anatomiques. . . voyage sur les côtes de la Sicile. . . vol. ii., par H. Milne-Edwards, A. de Quatrefages et E. Blanchard.

quarter of an inch; the subsequent changes are principally limited to alterations in the shape of the head and the gradual disappearance of the articulations, the only trace of them left being the corresponding convolutions of the digestive cavity. The oral and anal vibratile cilia disappear rapidly (figs. 12 & 13); the head becomes more rounded; the antennæ, having attained their maximum size (figs. 12 & 13), grow less and less prominent and rapidly vanish; so that the head of the young worm has now the shape of fig. 14, which was its condition four months after the stage represented in fig. 11. The articulations have become obliterated; no trace can be found of the pigment spots, which have gradually grown smaller and less numerous; and the young worm in its motions and attitudes reminds us strongly of *Nemertes* and the like Annelata. About a month later the head is even less prominent, and is separated from the body by the characteristic neck of the Nemerteans, the tentacles having altogether gone, the only trace of them being very slight swellings on each side of the head. The young worm loses at the same time its cylindrical shape, and in fig. 14 has already become greatly flattened. This is quite well shown in fig. 16, a profile view of fig. 15. The young Nemertean is now nearly half an inch long, and is usually found slightly coiled on the bottom of the jar in which it is kept; on being disturbed their motions are somewhat like those of the Nemerteans. The posterior extremity is much smaller than the anterior, the width of the worm increasing towards the head. As it grows older this difference is lost, the head becomes still less prominent, and finally, as in fig. 17, when the young worm is five months older than fig. 11, the width of the head is less than that of the body, and the eyes have moved nearer the neck.

There is but little doubt, from the foregoing observations, that Lovén's larva becomes eventually a Nemertean closely allied to *Polia*; my oldest larvæ, however, were far from being adults, and their generic affinities cannot be more closely intimated at present. There is little exceptional in the development of the larva from that of the other Annelids, as has been maintained; and, like other Annelids, it early assumes the features of the adult; and new rings are developed next to the anal ring, in accordance with the observations of all writers on the subject.

Spirorbis spirillum, Gould (non Pagenst., an Lam.?).

The history of the development of *Spirorbis* has been given in full by Pagenstecher*; I bring up the subject here to show

* "Untersuchungen über niedere Seethiere aus Cette. Entwicklungsgeschichte u. Brutpflege v. *Spirorbis spirillum*," in Zeits. f. wiss. Zool. 1863, xii. p. 487, pls. 38 & 39.

some differences in our observations, quite important as far as they bear upon the mode of development of the tentacles, and refer to a few features respecting the peculiar tendency of the development in these Annelids, which has not been sufficiently dwelt upon.

The species to which my observations are limited is found attached mainly upon *Fucus*. It is undoubtedly the *Spirorbis spirillum* of Gould*; but, judging from the differences existing between specimens of our coast and the descriptions of Pagenstecher, it certainly is not the *S. spirillum* of Lamarck investigated by him: the shape of the bristles of the three large clusters on the collar is totally different, as well as the arrangement of the small rods of the collar, which in our species form a single well-defined loop, placed immediately behind the posterior bundle of long bristles, entirely unlike the arrangement of the same parts as described by Pagenstecher.

The development of the eggs also takes place quite differently; and the present species, although furnished with a large, simple, funnel-shaped tentacle serving as an operculum, does not use it as an ovarian case as has been observed by Pagenstecher in *S. spirillum*, Lam. The eggs, of a dark reddish brown colour, are found in strings formed of two rows (fig. 18), either on each side of the alimentary canal in the anterior part of the body, where in the adult we find a considerable space free of bristles (as in fig. 25), or else when the strings have been laid they are found on the sides of the body, between it and the limestone tube, and here the young undergo their transformations. This is contrary to the statements of Pagenstecher, who says the young undergo their development in the funnel-shaped tentacle, used thus as a sort of breeding-case; it is, however, more in accordance with what we know of the method of laying eggs, within the tube in which they live, in *Terebella*, *Serpula*, and *Protula*.

As is already known from the observations of Milne-Edwards on *Protula*, the young lead a nomadic life but a short time, and soon build a tube in which they live and complete their growth. Pagenstecher has observed the same thing in *Spirorbis*; and it would appear from my own observations that the nomadic life of *Spirorbis* is not longer than eight or ten hours. The young *Spirorbis* has attained quite an advanced stage of growth when it leaves the tube of the parent and swims freely about (in search of a place of attachment) during a night at the outside; even with specimens kept in confinement, in perfectly clean glass vessels, the young escaping from the egg-cases are rarely caught while swimming about; it frequently happens

* Report on the Invertebrates of Massachusetts, 1841, p. 8.

during a night that the smooth sides of the vessel are completely covered with small limestone tubes, formed by the young *Spirorbis* hatched since the evening before.

We may perhaps find in our *Spirorbis* the explanation of the anomalous development of *Terebella Medusa** observed by Spence Bate, in what he calls uterine sacs, which may prove identical with the tubes containing the eggs and forming strings (fig. 18) which I have observed in this species, placed on each side of the alimentary canal, in the naked part of the body immediately behind the collar. The young are quite advanced within the body of the parent previously to the transfer of the egg-sacs to the cavity of the tube, where they complete the greater part of their growth. Spence Bate says these sacs pass through the intestinal canal into the tube: this seems scarcely possible; but, in whatever manner this may be done, the string of eggs find their way whole from the sides of the alimentary canal to the cavity of the tube.

As I shall have to refer constantly to the development of the tentacles in *Terebella* as observed by Milne-Edwards, I give here a short description of an identical mode of development in one of our common species—the *Terebella fulgida*, Agass.† The figure represents it at a time when there are but five tentacles and no signs of the branchiæ; these are only developed much later, when there are no less than from sixteen to eighteen tentacles, and are at that time short processes with very simple bifurcations appearing at the extremity. In the condition here figured (fig. 19) our young *Terebella* closely resembles fig. 24 of Milne-Edwards, at the time when, as shown by him, they are more closely allied to rapacious Annelids, before they lose their embryonic characters and acquire more distinctly those of the adult. The eyes are still in prominent clusters and not yet formed into a ring round the collar as they are arranged while gradually disappearing; below them we find on each side of the body the concretions (fig. 19 *γ*) first seen in Annelids by Leuckart‡ and Fritz Müller§, and also observed by Claparède in the young of his *Terebella conchilega*. This is the only point of importance in which the young of *Terebella fulgida* differ from those of *Terebella nebulosa*: in each we find, as in fig. 19, tentacles developing alternately on opposite sides, in the order marked in the figure; the first ring having dorsal setæ has also a row of hook-shaped bristles (fig. 19^a), found in each ring nearly to the posterior extremity. This combination

* "On *Terebella Medusa*," in Ann. & Mag. Nat. Hist. 1851, viii. p. 237.

† "Studies in Annelids," in Proc. Boston Soc. Nat. Hist. iii. p. 191.

‡ Leuckart u. Pagenstecher, in Archiv f. Anat. u. Phys. 1858, p. 591.

§ Archiv fur Naturg. 1861, l. p. 46.

is different from that observed by Claparède in *T. conchilega*, where no such hook-shaped bristles were observed before the fifth ring. The description given by Stimpson* of the genus *Lumara* agrees so well with some of the stages of *Terebella*, that I am inclined to consider it only an embryonic condition of some allied *Terebella*. Long after the stage here figured, even when the branchiæ have become quite well developed, it is very common to fish up with the dip net these young *Terebella*, which are capable of a certain amount of motion by the contortions of the tentacles and body. They build their cases very late, and frequently leave them, to climb about on eel-grass, piles, &c., making considerable progress with the aid of their tentacles, by which they drag themselves along.

Pagenstecher has invariably represented the tentacles of the anterior extremity of *Spirorbis* as developing symmetrically and in pairs. This is not the case in our species, where they are formed very differently from what has been thus far observed in this family. We have between these two modes of growth a difference similar to that existing between *Terebella nebulosa* and *T. conchilega*, where in one case the tentacles appear successively, while in the other they are formed in pairs. The oldest tentacles of our *Spirorbis* are formed on the outside, new tentacles appearing successively singly nearer the median line on alternate sides, and not in pairs, the corresponding tentacles on each side of the middle line being of very different lengths. This want of symmetry is readily seen in the youngest specimens figured (figs. 20, 21, 22); and though it is more difficult to trace this in older stages (fig. 25), the presence of the simple opercular tentacle always introduces a prominent asymmetrical element, soon lost in the more advanced stages of the development of *Terebella*. The two eyes are quite prominent, and can generally be traced in the adult, although they are not so striking as in the younger stages; the ocular spots are always limited to two, and we find at no time either a ring or clusters of eye-specks.

The first tentacle appears on the right (fig. 20 t_1); next comes the corresponding tentacle of the left, and only later (fig. 21) the rudiment of the odd opercular tentacle (t_0 , fig. 22), covering in fig. 21 the right tentacle. The bristles make their appearance in fig. 21, where we find two of the three bundles of the collar-like projection of the anterior extremity, always distinctly marked in such young embryos. In the next stage the collar is more prominent, and an additional bristle is found, representing the third bundle of the collar (fig. 22). The pos-

* Marine Invertebrates of Grand Manan, 1853, p. 30.

terior extremity has lengthened, the anal cirri have nearly disappeared, and a couple of very indistinct articulations can be traced behind the collar. There are also two additional tentacles placed between the first pair, which readily show in what order they have appeared (t_2 , t_3), the opercular tentacle always retaining its peculiar shape.

In subsequent stages (fig. 23) the posterior extremity has lengthened but slightly. There are along the side of the posterior part of the body a couple of bristles similar to those of the adult; we can trace the first stage of the bifurcation of the four tentacles at their extremity, rendering the age of the tentacles more apparent, as in fig. 24; the opercular tentacle has become more funnel-shaped. At about the period represented in fig. 23, the young *Spirorbis* escapes from the egg, and leads a short nomadic life; it soon attaches itself, and in less than twelve hours after hatching has built its limestone tube, in which it henceforth lives: subsequent observations can only be made by crushing the shell, as it is not transparent enough to show the young worm. The tentacles take a rapid development; and in fig. 25 we have a small *Spirorbis* having only nine rings, with tentacles nearly as branching as those of the adult, and a well-formed operculum, which with advancing age loses all trace of its former tentacular nature. The tentacular nature of the operculum in this family has also been observed by Fritz Müller*.

The principal changes take place almost exclusively in the anterior extremity; the posterior part of the body does not lengthen until the collar and tentacles may be said to be fully developed; and although we find papillæ on the sides of the posterior part of the body similar to those forming the single loop of the collar of the adult, as well as the peculiar scythe-shaped bristles of each ring, yet the young *Spirorbis* has, up to this time, passed through no phase of growth during which the increase of the posterior part was in the least to be compared with the changes of the anterior extremity. In nearly all other Annelids we find the posterior extremity playing a much more prominent part in determining the shape of the young worm. This is undoubtedly due to the shortness of their nomadic life; and though capable of active movements during that period by means of the collar, their freedom soon comes to an end, and they complete their development after having assumed the habits of the adult.

[To be continued.]

* Für Darwin. Leipzig, 1 64.